

# BELLCOMM, INC.

955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B70 06097

SUBJECT: Use of ARIA for Support of  
Skylab A. Case 900

DATE: June 30, 1970

FROM: A. G. Weygand

## ABSTRACT

The communications support coverage of the Saturn Workshop (SWS) of mission SL-1 of the Skylab Program provided by existing land-based stations of the Manned Space Flight Network (MSFN) during the first 50 minutes after insertion of the SWS into Earth orbit is examined. It is shown that some of the programmed sequenced events performed by the SWS under control of the Instrument Unit (IU) such as jettison of the Payload Shroud (PS), acquisition of the solar inertial attitude and deployment of the solar arrays of the Apollo Telescope Mount (ATM) and Orbital Workshop (OWS) which are critical to mission success will occur when the SWS will not be within line-of-sight of a land-based station of the MSFN. Data necessary for post mission analysis of these critical events will be included in the data transmitted in real-time from the Airlock Module (AM) via a VHF telemetry link and from the Instrument Unit (IU) via the S-band Command and Communications System (CCS). Retrieval of this data is highly desirable from the standpoint of incorporating fixes in the backup SWS in the event that the primary SWS fails to perform any of the mission critical programmed sequenced events causing cancellation of subsequent manned visit missions to the SWS.

From strictly geometrical considerations, three ARIA plus the Vanguard (an Apollo instrumentation ship) would be sufficient to fill the gaps in telemetry support of the SWS during the time period of interest when the SWS is not within line-of-sight of any of the MSFN stations. However, the predicted performance of the AM to ARIA VHF telemetry link discussed in this memorandum suggests that at least three additional ARIA, and possibly more, would be required to fill these coverage gaps because of the limited range over which the ARIA can support the VHF telemetry link from the AM. Instead of using ARIA, it is suggested that the data required for post mission analysis of the programmed sequenced events be recorded on-board the AM using existing equipment and be dumped at a later time to a land-based station of the MSFN.

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MEMORANDUM FOR FILE

**1.0** INTRODUCTION

The potential requirement for continuous telemetry support of the Saturn Workshop (SWS) of mission SL-1 of the Skylab Program (or Skylab A) to permit post flight analysis of the performance (or lack thereof) of the sequencing functions scheduled to be completed within approximately the first 45 minutes after insertion of the SWS into Earth orbit is discussed in this memorandum. There are five major sequencing functions: jettison of the Payload Shroud (PS), deployment of the Apollo Telescope Mount (ATM), deployment of the solar arrays of both the ATM and the Orbital Workshop (OWS), and acquisition of the solar inertial attitude such that the plane of the solar arrays is perpendicular to the Earth-Sun line. The Launch Vehicle Digital Computer (LVDC) located in the Instrument Unit (IU) which is part of the SWS will provide programmed commands which will initiate these sequenced functions as well as initiating deployment of the VHF/UHF discone antennas of the Airlock Module (AM) and deployment of the meteoroid shields of the OWS via operation of appropriate switch selectors. Failure to perform any one of these five major functions would be sufficient cause to cancel the succeeding manned visit missions (SL-2, SL-3, and SL-4) to the Skylab A. Failure to deploy the VHF/UHF discone antennas or the OWS meteoroid shields would most likely not be sufficient to cancel mission SL-2. Consequently, it appears highly desirable to be able to determine the cause of the failure to perform any of these five major functions so that a fix could be incorporated if necessary into the backup hardware (or Skylab B) to preclude a similar failure.

It should be noted that any one of the LVDC programmed sequence events discussed above could be commanded from the ground via the up-data link to the IU. In addition, with the exception of the jettison of the PS, each of these events could also be commanded from the ground via the up-data link to the AM. Commands will be transmitted from a station of the Manned Space Flight Network (MSFN) to the Command and Communications System (CCS) of the IU via an S-band carrier and

to the UHF Digital Command System (DCS) of the AM via a 450 MHz carrier.

Verification that these programmed sequence events have occurred, with the exception of the acquisition of the solar inertial attitude, will be provided to the ground via the real-time VHF telemetry link from the AM. Information will also be included in the data transmitted via the real-time telemetry link from the AM which will facilitate malfunction analysis of the ordnance circuits which must operate to initiate each of the major programmed sequence events. Information on the attitude of Skylab A during these early periods of mission SL-1 will be provided to the ground by a real-time telemetry link from the IU via the CCS.

Although the timeline from the programmed sequence of major events has yet to be finalized, preliminary information indicates that the major events discussed above will nominally be completed within 35 to 50 minutes after the SWS of mission SL-1 has been inserted into Earth orbit. Figure 1 shows a map of the world with the ground track of the nominal orbit (a circular Earth orbit of 235 nautical miles altitude with an inclination of 50 degrees) of the SWS starting at the Earth orbit insertion point superimposed. If the ground track enters one of the circles superimposed on this map, line-of-sight will be established between the point on the Earth at the center of the circle and the SWS in its 235 nautical mile orbit above an assumed line-of-sight mask of three degrees above the local horizon of the station. Assuming the use of only existing stations of the MSFN at Bermuda (BDA), Madrid (MAD), Carnarvon (CRO), and Honeysuckle Creek (HSK) as shown in Figure 1, continuous real-time telemetry reception by the existing land-based stations of the MSFN from the SWS will not be possible during that portion of the first Earth orbit of interest. A proposal has been made to use the Apollo/Range Instrumentation Aircraft (ARIA) to receive and record real-time telemetry transmissions from the SWS during that period of interest of the first orbit when line-of-sight does not exist between a land-based station of the MSFN and the SWS.

The use of ARIA to provide the indicated telemetry support of the SWS is examined in the following paragraphs and an alternative method of obtaining the desired data for post mission analysis is suggested. The current timeline for the programmed sequenced events and related mission constraints are presented in Section 2.0. The communications support coverage of the SWS provided by existing land-based stations of the MSFN and a possible strategy for use of ARIA and the Apollo instrumentation ship to provide the additional indicated coverage are

discussed in Section 3.0. Characteristics of the telemetry subsystems of the AM and the IU, the extent of the data included in the telemetry link from the AM pertaining specifically to these programmed sequenced events, and the telemetry support capabilities of the ARIA including a discussion of the communications performance margins for the telemetry links of interest are summarized in Section 4.0. The results of this examination of the use of ARIA to support Skylab A are presented and an alternative method of obtaining the required data for post mission analysis is suggested in Section 5.0.

## 2.0 TIMELINE FOR THE PROGRAMMED SEQUENCED EVENTS

Following is an approximate timeline for the programmed sequence of major events controlled by the LVDC in the IU. Also included is a brief discussion of the mission constraints related to these programmed sequenced events.

Immediately after the spacevehicle of mission SL-1 has been inserted into Earth orbit and the S-II stage engine thrust has decayed, the S-II stage will be separated from the SWS by firing the S-II stage retrorockets. Immediately after separation of the S-II stage, the SWS under IU control will begin a pitch rotation maneuver in the nose down direction which when completed will leave the SWS in the retrograde attitude (MDA pointing in the direction opposite the SWS velocity vector.) During this pitch rotation maneuver as the SWS passes through the nose down position (MDA pointing toward the Earth) which will occur approximately five minutes after insertion, the PS will be jettisoned. No attempt will be made to deploy the VHF discone antennas of the AM or to deploy the ATM until the PS has been successfully jettisoned. After PS jettison but before ATM deployment, the VHF discone antennas will be deployed. After the SWS has reached the retrograde attitude which will occur at approximately 11 minutes after insertion, the ATM will be deployed (rotated from the plus X-axis of the SWS to the minus Z-axis of the SWS) taking approximately five minutes. No attempt will be made to deploy the ATM solar arrays until the ATM has been successfully deployed. At approximately orbital midnight, which will occur at approximately 30 minutes after insertion, the SWS will acquire and then maintain a solar inertial attitude under IU control. Switchover of attitude control from the IU to the ATM digital computer must be accomplished before 7.5 hours after life-off because that is the design lifetime of the battery power supply of the IU. The ATM digital computer cannot successfully assume control of the attitude of the SWS until the ATM has been successfully deployed. Activation of the Control Moment Gyros (CMG's) will begin after deployment of the OWS solar arrays.

There is some uncertainty as to the exact timing of the deployment of the ATM and OWS solar arrays. A mission constraint does exist, however, which states that, based on first orbit deployment, the OWS solar array deployment cannot be deployed earlier than 3105 seconds prior to orbital noon nor later than 610 seconds after orbital noon (assuming an orbit period of 5580 seconds) in order to avoid permanent damage to the array caused by thermal effects. The ATM and OWS solar arrays may be deployed as early as 30 minutes after insertion or as late as 48 minutes after insertion according to different proposed timelines. The ATM solar arrays will be deployed first. The OWS solar arrays will then be deployed. The OWS solar array beams must be successfully deployed before the solar array wings can be deployed. After successful deployment of the OWS solar arrays, the OWS meteoroid shields will be deployed. No effort will be made to deploy the meteoroid shields until the OWS solar arrays have been deployed. There are additional programmed sequenced events controlled by the IU, but they occur significantly later in the mission. It should be noted that all electronic equipment mounted on the ATM rack or in the MDA end of the ATM canister must be activated not later than two hours after launch to avoid permanent damage to electronic equipment resulting from equipment temperature falling below allowable limits.

Among the prerequisites for a commit to launch decision for mission SL-2 are validation of the occurrence of the following events on the SWS of mission SL-1:

- (a) S-II stage separated,
- (b) PS separated,
- (c) ATM deployed,
- (d) ATM solar arrays deployed,
- (e) OWS solar arrays deployed,
- (f) Solar inertial attitude acquired and maintained,
- (g) ATM pointing control system activated and providing attitude control of SWS, and
- (h) Communications between SWS and MSFN established.

### 3.0 COMMUNICATIONS SUPPORT COVERAGE

Line-of-sight contact times provided between the SWS and the existing stations of the MSFN above a three degree station horizon mask was calculated for the first 100 minutes after insertion of the SWS into a circular Earth orbit of 235 nautical miles altitude with an inclination of 50 degrees. The SWS insertion point used in this analysis was 68.2219 West longitude and 37.9516 North latitude. The effects of nulls in the SWS antenna patterns, ground antenna gimbal-lock pointing restrictions, finite signal acquisition times, and atmospheric refraction of radio frequency signals were neglected in these calculations. These data are summarized in Figure 1 for the first 60 minutes after insertion of the SWS in Earth orbit. Although there are more stations in the MSFN than those that are shown in Figure 1, only the BDA, MAD, CRO, and HSK MSFN stations have line-of-sight contact with the SWS during the time period of interest.

As can be seen from Figure 1 with reference to the timeline for programmed sequenced functions discussed in Section 2.0, some of the programmed functions such as jettison of PS, acquisition of the solar inertial attitude and deployment of the ATM and OWS solar arrays will be performed during periods when line-of-sight between a station of the MSFN and the SWS will not exist. Consequently, if data required for post mission analysis of the performance of the programmed functions can only be obtained by receiving and recording the data transmitted from the AM and the IU in real-time, means must be provided to cover the gaps between line-of-sight contacts with the SWS by successive MSFN stations. Each of the MSFN stations shown in Figure 1 currently has the capability to support the CCS of the IU which is a Unified S-Band (USB) type of communications link. However, of those MSFN stations shown in Figure 1, both the MAD and HSK MSFN stations do not presently have the capability to support the VHF telemetry links from the AM or the UHF command link to the AM. For the purposes of this analysis, it was assumed that the necessary VHF telemetry support and UHF up-data support capabilities will be added to the MAD and HSK stations before the first scheduled launch in the Skylab Program.

The line-of-sight contact gap between the point where the BDA station loses contact with the SWS and the point where the MAD station acquires contact with the SWS could easily be eliminated by proper position of the Vanguard, an instrumentation ship from the Apollo Program which is currently required to support the launch phase of the manned launches of the Skylab Program. The Vanguard already has the required capabilities to support the CCS of the IU and the VHF telemetry and UHF

command links of the AM.

Depending upon the finalized schedule for ATM and OWS solar array deployment and OWS meteoroid shields deployment, most of or the entire line-of-sight contact gap between the point where the MAD station loses contact with the SWS and the point where the CRO station acquires contact with the SWS must be covered or desired data will be lost. From the geometry of the situation, it appears that at least three ARIA will be required to cover this gap regardless of when deployment of the ATM and OWS solar arrays is initiated in the current range of from 30 to 48 minutes after insertion of the SWS in Earth orbit. Assuming the ARIA were evenly spaced along the ground track of the SWS to provide the necessary line-of-sight contact with the SWS, the major difference between the two extreme cases will be the maximum range over which communications must be conducted between the ARIA and the SWS. It should be noted that the ARIA as presently configured can provide receive support of the CCS link from the IU and the VHF telemetry links from the AM but cannot provide up-data support of the AM via the UHF command link nor of the IU via the CCS link.

#### 4.0 IU AND AM TELEMETRY SUBSYSTEM CHARACTERISTICS AND ARIA TELEMETRY SUPPORT CAPABILITIES

Since the characteristics of the telemetry subsystem and the CCS of the IU will be identical to those of the corresponding subsystems of the IU of the Saturn V Launch Vehicles of the Apollo Program, these characteristics will not be summarized in this section. The characteristics of the AM telemetry subsystem and a discussion of the data on the performance of the programmed sequenced events of interest included in the total data telemetered from the AM in real-time are presented in Section 4.1. A discussion of the predicted performance margin of the telemetry links from the AM and IU to the ARIA is presented in Section 4.2.

#### 4.1 TELEMETRY SUBSYSTEM OF THE AIRLOCK MODULE

The telemetry subsystem of the AM is composed of the Pulse Code Modulation (PCM) telemetry equipment and a radio frequency transmission subsystem.

##### 4.1.1 PCM Telemetry Equipment

The PCM telemetry equipment of the AM will convert and combine all of the analog and digital signals received from the measuring subsystems of the OWS, AM, and Multiple Docking Adapter (MDA) into a single serial binary coded (PCM) signal

of 51.2 kilobits per second (kbps). This PCM signal will contain all of the housekeeping and post mission analysis type data on MDA, AM, and OWS subsystems as well as data from experiments conducted in the MDA/AM/OWS.

Data included in this 51.2 kbps PCM signal which pertain solely to the verification of or to the post mission analysis of the performance of the major programmed sequencing events has currently been defined to consist of 28 discrete (on/off) measurements and 26 analog measurements. Four of these discrete measurements will be used to verify that the redundant deploy buses and the redundant sequential buses of the AM have been powered. Monitoring of the PS jettison function will be accomplished by four discrete measurements which verify separation of the four PS segments from the SWS and 12 analog measurements which monitor the charge condition of the firing units for the latch and separation joint exploding bridgewires (EBW's). Monitoring of the ATM deployment function will be accomplished by two analog measurements which monitor the charge condition for the firing unit of the redundant ATM deployment assembly latch release pyrotechnics, two discrete measurements which verify that power has been applied to the redundant deploy motors, and two discretes which indicate that the ATM deployment assembly has been locked in the deployed position. Monitoring of the SWS solar array deployment will be accomplished by four analog measurements which monitor the charge condition of the redundant firing units for the solar array fairing release EBW's and for solar array wing section release EBW's, four discrete measurements which indicate that the two solar array wing fairings are secured in the launch position or that the solar array beams have been properly deployed, and six analog measurements which monitor the per cent of full deployment for each of the six solar array wings. Monitoring of deployment of the ATM solar array system will be accomplished by two discrete measurements which indicate that power has been applied to the ATM solar array system deploy circuits. Monitoring of the deployment of the VHF discone antennas of the AM will be accomplished by one discrete measurement which indicates that the hot wire actuators have been activated and two discrete measurements which indicate that the antennas have been deployed. Monitoring of the deployment of the OWS meteoroid shield will be accomplished by two analog measurements which monitor the voltages supplied to the redundant EBW's, and seven discrete measurements which indicate that the meteoroid shields are in the stowed position or that the meteoroid shields have been fully deployed.

The 51.2 kbps PCM signal generated by the PCM telemetry subsystem of the AM will be transmitted to the MSFN in



real-time. Three different and exclusive subsets of this PCM signal, each consisting of 5.12 kbps and called a subframe, will be extracted singly or in parallel from the signal and may be stored on-board for later transmission to the MSFN. Three tape recorders will be carried by the AM and each will be capable of recording one 5.12 kbps signal. The tape recorders may be operated manually by a crewman or by command from the ground.

To date, the sampling rates required for each of the 28 discrete and 26 analog measurements have not been established nor has it been established whether this data will be included in any one of the three 5.12 kbps PCM signals or subframes which will be made available for on-board storage.

#### 4.1.2 Radio Frequency Transmission Subsystem

Four VHF FM telemetry transmitters will be carried by the AM. Each transmitter will be capable of transmitting one PCM signal to the MSFN, either the 51.2 kbps PCM signal generated in real-time or a PCM signal dumped from storage by one of the tape recorders. Three of the four VHF telemetry transmitters will only be used during prelaunch checkout and Earth orbital phases of the SWS mission in order to avoid possible permanent damage to these transmitters caused by high voltage breakdown of the air in the vented transmitter packages at critical pressures encountered during the launch and early Earth orbital phases of the mission until the packages have vented sufficiently. The output power of each of the three transmitters will be ten watts minimum. The fourth VHF telemetry transmitter will have an output power of 2 watts minimum and will operate at the same carrier frequency as one of the three ten watt transmitters. During the launch phase of the SL-1 mission and during the early portions of the Earth orbital coast phase, the two watt transmitter will be used to transmit the 51.2 kbps PCM signal generated in real-time. After sufficient time has elapsed to ensure that the ten watt transmitter packages have vented sufficiently so that internal gas pressures are below the critical pressure region, the two watt transmitter will be deactivated and the corresponding ten watt transmitter will be activated by command from the ground. It is not clear at this time when the ten watt transmitter will first be used to transmit the real-time 51.2 kbps PCM signal during Earth orbital coast.

The AM will be provided with two VHF antenna subsystems; namely, (a) the launch antenna subsystem, and (b) the Earth orbit antenna subsystem. A multiplexer will be provided

to permit three VHF transmitters operating at different carrier frequencies to share the two VHF antenna subsystems. The launch antenna subsystem will consist of a linearly polarized VHF stub antenna mounted on the fixed portion of the PS between the plus Y and plus Z axes of the SWS and 45 degrees from the plus Y axis. The Earth orbit antenna subsystem will consist of two linearly polarized VHF discone antennas, each deployed on a different non-retractable boom forty feet in length after the PS has been jettisoned. The booms will be located +45 degrees from the plus Z axis of the SWS. The combined output from the VHF multiplexer may be switched to the stub antenna of the launch antenna subsystem or to either one of the two discone antennas of the Earth orbit antenna system via coaxial switches which may be operated manually by a crewman or by command from the ground.

#### 4.2 TELEMETRY LINK PERFORMANCE MARGIN CALCULATION

The calculation of the expected quality of the performance of the VHF telemetry link from the AM to an ARIA is discussed in this section. From experience gained during the Apollo Program, it is expected that the performance of the CCS telemetry link from the IU to an ARIA will be acceptable for the maximum slant ranges of interest. Consequently, the performance of the CCS telemetry link will not be discussed further.

If it is desired to limit the number of ARIA used to the minimum number required to fill the gap between coverage provided by the MAD and CRO MSFN stations plus the required spares, the maximum communications range between the SWS and an ARIA will be approximately 1200 nautical miles. This assumes that the ARIA will be flying at an altitude of approximately 5 nautical miles and that communications will be conducted at elevation angles as low as approximately 2 degrees from the local horizontal of the ARIA. It should be noted that operation at these low elevation angles with the wide beamwidth provided by the VHF antenna (approximately 40 degrees) of the ARIA may introduce multipath problems from sea reflections. Multipath effects were not considered in this analysis.

The results of the calculation of the AM to ARIA telemetry link performance margin for a range of 1200 nautical miles are presented in Table 1. It was assumed that the 2 watt transmitter of the AM would be used to transmit the real-time 51.2 kbps PCM signal. As indicated earlier, a 10 watt transmitter will be available on the AM to transmit this real-time PCM signal, however, this transmitter cannot be activated until there is adequate assurance that the pressure of the air remaining inside of the vented transmitter package has reached a value below the critical breakdown pressure region or permanent

damage to the transmitter may result. At this time, it is not clear when it will be safe to activate one of the 10 watt transmitters. The possibility does exist that the 10 watt transmitter could be activated by ground command when the SWS has line-of-sight with the MAD MSFN station, thereby providing an additional 7dB of performance margin.

Although -3dB was used as the gain of the AM VHF antenna in the calculation, the actual gain could be substantially less than -3dB or somewhat greater than -3dB. As indicated earlier, the AM will be provided with a launch antenna subsystem and an Earth orbit antenna subsystem. The launch antenna subsystem must be used for VHF telemetry transmissions at least until the PS has been deployed and the two antenna booms of the AM, each with a VHF discone antenna, have been successfully deployed. During nominal operations, the antenna element providing the best radiation pattern for communications with a particular station of the MSFN will be selected remotely from the ground via the UHF command link to the AM. Since an ARIA does not have the capability to transmit commands to the AM, one of the three antenna elements (the VHF stub antenna of the launch antenna subsystem or either one of the two VHF discone antennas of the Earth orbit antenna subsystem) chosen for use by command from the MAD MSFN station must be used exclusively until SWS contact with the CRO MSFN station is established. During this portion of the SWS mission, the attitude of the SWS will change substantially. When line-of-sight contact between the SWS and the MAD MSFN station is lost, the SWS will be stabilized in the retrograde attitude. A short time later, the SWS will acquire and then remain stabilized in a solar inertial attitude with the minus Z-axis of the SWS pointing in the direction of the Sun. Although measured antenna radiation patterns are not available, it appears reasonable that the same antenna element would not provide the best radiation pattern toward the relative position of the ARIA for the range of possible SWS attitudes and ARIA positions relative to the SWS. Furthermore, if the VHF discone antennas were not deployed, the VHF stub antenna of the launch subsystem would have to be used. During the period of postulated ARIA support, the plus Z-axis of the SWS will generally be pointing away from the Earth while the VHF stub antenna will be located midway between the plus Y and plus Z-axes of the SWS. Therefore, it seems likely that the radiation pattern of this antenna toward the various relative positions of the ARIA with respect to the SWS will be less than -3dB with respect to an isotropic antenna radiation pattern.

As is shown in Table 1, the calculated margin for the AM to ARIA telemetry link performance over a range of 1200 nautical miles is -10.6dB. This may be interpreted as meaning that the maximum range over which the ARIA can support the VHF telemetry link from the AM is approximately 340 nautical miles. It is apparent that the number of ARIA required to cover the gap between SWS contacts with the MAD and CRO stations would far exceed the number of ARIA currently available if the maximum range between the ARIA and the SWS for acceptable communications were limited to 340 nautical miles.

If one of the 10 watt transmitters could be used in place of the 2 watt transmitter for transmission of AM telemetry data during the time period of interest, the ARIA could support the real-time VHF telemetry link from the AM over a maximum range of approximately 760 nautical miles. This increased range capability reduces the number of ARIA required to cover the gap between SWS line-of-sight contacts with the MAD and CRO MSFN stations to six plus spares.

#### 5.0 SUMMARY AND SUGGESTIONS

Some of the programmed sequenced events performed by the SWS under control of the IU during the first 50 minutes after insertion of Skylab A into Earth orbit which are critical to the mission success will occur when Skylab A is not within line-of-sight of one of the existing land-based stations of the MSFN (see Figure 1). Data necessary for post mission analysis of these critical events will be included in the real-time telemetry links from the AM and the IU. Retrieval of this data is highly desirable from the standpoint of incorporating fixes in Skylab B if necessary as a result of SWS failure to perform any of the mission critical programmed sequenced events causing cancellation of manned visit mission to Skylab A. A proposal has been made to use ARIA to record the data transmitted by the AM and IU telemetry links during those time periods of interest when the SWS is not within line-of-sight of a land-based station of the MSFN. It was assumed that the Vanguard (Apollo instrumentation ship) would be used to fill the communications gap between the BDA and MDA MSFN stations.

It is possible that the VHF discone antennas of the AM will fail to deploy and that the VHF stub antenna of the launch antenna subsystem of the AM must be used for all telemetry transmissions. If the VHF discone antennas are deployed, radiation from only one of three possible antenna elements (the VHF stub antenna of the launch antenna subsystem or either one of the two VHF discone antennas of the Earth orbit antenna subsystem) of the

AM will be possible at any given time and selection of the antenna element to be used will be accomplished by ground command. However, the ARIA do not have the capability of transmitting commands to the AM and the attitude of the SWS will be changing from a retrograde attitude to a solar inertial attitude during this time period. Consequently, the antenna element chosen for use may not provide the best radiation pattern of those available for a given relative location of an ARIA with respect to the SWS thereby reducing the range over which an ARIA can support a telemetry link of the AM. In addition, use of one of the 10 watt transmitters of the AM in place of the 2 watt transmitter used during the launch phase may not be possible during this time period of the SWS mission to avoid causing permanent damage to the 10 watt transmitter through the mechanism of high voltage breakdown resulting from operation of the transmitter before air in the transmitter package has been sufficiently vented. Use of a 10 watt transmitter for telemetry transmissions from the AM may be selected by ground command. If the use of a 10 watt transmitter is assumed, the maximum slant range over which the ARIA can support the AM telemetry link is predicted to be approximately 760 nautical miles. Therefore, if the ARIA are assumed to be equally spaced along the ground track of the SWS, six ARIA plus spares will be required to fill the communications coverage gap between the MAD and CRO MSFN station line-of-sight contacts with the SWS. It was assumed in this analysis that VHF telemetry receive support and UHF up-data transmission support capabilities will be added to both the MAD and HSK MSFN stations before the Skylab A launch date. Depending upon the time when deployment of the ATM and OWS solar arrays is initiated, an ARIA may also be required to provide SWS telemetry support during the communications coverage gap between the CRO and HSK MSFN station line-of-sight contacts with the SWS (See Figure 1). If the 2 watt transmitter must be used during this time period of interest, the maximum slant range over which the ARIA can support the real-time telemetry link from the AM is predicted to be approximately 340 nautical miles. It is obviously impractical to consider use of ARIA under such circumstances. It should be noted that from experience in the Apollo Program that the ARIA will be capable of supporting the CCS telemetry link from the IU over slant ranges greater than 760 nautical miles.

As indicated earlier, 38 discrete (on/off) measurements and 26 analog measurements have been identified at this time pertaining solely to the performance of the programmed sequence events and these will be included in the data telemetered

in real-time from the AM. As yet, the required sampling rates for these measurements have not been identified nor has it been determined whether this data will be included in any one of those subsets of the real-time 51.2 kbps PCM data signal generated by the PCM telemetry equipment called subframes which will be made available for storage on tape recorders of the AM. As an alternative to the use of ARIA to retrieve data for post mission analysis of the performance of the programmed sequenced events, it is suggested that all data necessary for this post flight analysis including attitude data from the IU be included in one or more of these recordable subframes which would then be stored by the tape recorders of the AM during those time periods of interest when line-of-sight contact between the SWS and existing stations of the MSFN did not exist. This stored data could be dumped to any station of the MSFN upon command from that station at some later time.

Since the capabilities now exist for the tape recorder of the AM to be controlled by ground command, the MAD MSFN station could transmit commands to the AM to configure the telemetry and data storage subsystems of the AM properly so that the data required for post mission analysis of the performance of the programmed sequenced events could be stored on-board the AM. Since each of the tape recorders of the AM has a continuous record capability of 4 hours and an end of tape sensor which will automatically shut off the tape recorder, close control of the tape recorders would not be required after initial activation. Thus the recorders could be used to store data on events occurring after line-of-sight contact with the HSK MSFN station is lost by the SWS and to playback the stored data to any station of the MSFN whenever convenient. The data stored by the tape recorders will not be destroyed during playback thereby enabling the stored data to be transmitted to the ground multiple times in the event that the first transmission of tape recorder playback data is not successfully received by a station of the MSFN.

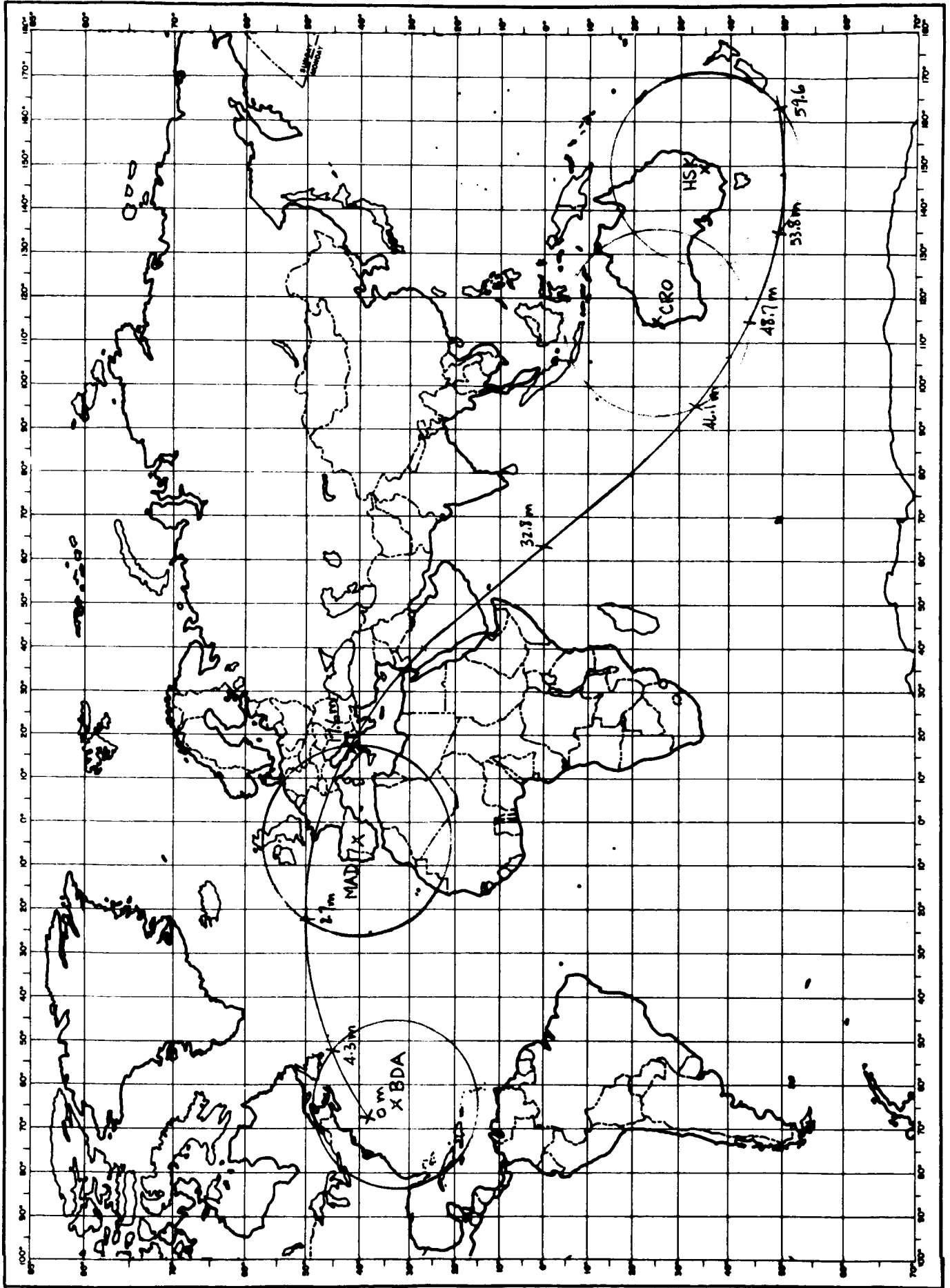
It is possible that there will not be a sufficient number of spare channels in the format for the primary subframe of the 51.2 kbps PCM signal generated by the PCM telemetry equipment of the AM to accommodate these measurements on the performance of the programmed sequenced events. Under current plans, the primary subframe will include the minimum amount of the housekeeping data on MDA, AM, and OWS subsystems needed during the active mission by flight controllers at the Mission Control Center (MCC) for trend analysis and malfunction detection during those periods when the SWS is not within line-of-sight of an MSFN station. The primary subframe will usually be recorded during those periods and will be dumped when line-of-sight

between the SWS and an MSFN station is again achieved. Also under current plans, the remaining subframes which can be made available for recording will largely include data from experiments. Since there are insufficient channels available in the formats for these subframes to accommodate the data from all experiments simultaneously, some of the channels will be time-shared by various experiments which will never be conducted simultaneously. The switching of input data to these channels will be accomplished manually by a crewman on-board Skylab A. If the format for the primary subframe cannot accommodate the additional measurements for post flight, it is suggested that those channels already time-shared by experiment data in one of the recordable subframes be used to accommodate these additional measurements. This appears attractive because experiments will not be conducted during the performance of the programmed sequenced events and, after activation of Skylab A when experiments will be conducted, measurements of parameters for assessment of the performance of the programmed events will be meaningless. Thus when the crew arrives at the Skylab A, a crewman could manually switch data from appropriate experiments into those channels used for data on the performance of the programmed events. Consequently, recording of two subframes would most likely be required during those time periods of interest during the activation of Skylab A. The AM currently has the capability to record two subframes simultaneously and to transmit the playback of the stored data from two tape recorders simultaneously with transmission of the real-time 51.2 kbps PCM data signal generated in the AM.

2034-AGW-pjr

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Figure 1 - Line-of-Sight Contact From MSFN Stations with a 3 Degree Horizon Mask to Skylab A During the First Earth Orbit





BELLCOMM, INC.

Table 1

AM to ARIA Telemetry Link Performance Margin  
for a Range of 1200 Nautical Miles

1. Transmitter power (2.0 watts)	+3.0 dBW
2. Transmission line losses between Transmitter and antenna	-4.0 dB
3. Transmit antenna gain	-3.0 dB
4. Polarization and receive antenna pointing loss	-3.0 dB
5. Free space loss (range - 1200nm; transmitter frequency = 246.3MHz)	-147.2 dB
6. Receive antenna gain	12.0 dB
7. Transmission line losses between antenna and preamplifier	-3.1 dB
8. Total signal power received by the ARIA	-145.3 dBW
9. Receiver noise spectral density (antenna noise temperature = 290°K; Transmission line temperature = 290°K; preamplifier noise figure = 4.5 dB)	-199.5 dBW
10. Receiver IF bandwidth (300kHz)	+54.8 dB
11. Total noise power in the ARIA receiver	-144.7 dBW
12. Received signal-to-noise ratio	-0.6 dB
13. Required signal-to-noise ratio for discriminator threshold	10.0 dB
14. Telemetry link performance margin	-10.6 dB